The Place of Mathematical Models in Psychology and the Social Sciences

Comments on the article by Brown, Sokal, & Friedman (2013)

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Running Head: The Place of Mathematical Models in Psychology and the Social Sciences

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In the article "The Complex Dynamics of Wishful Thinking" (Brown, Sokal & Friedman, December 2013), Brown et al. presented a scathing critique of the work of Fredrickson and Losada (2005) on the use of advanced mathematical methods (specifically, nonlinear dynamics) in describing changes in human emotions over time, terming it "entirely unfounded" (p. 802). However, I feel that although their critique serves an important role in identifying potential flaws in the theory, it goes too far by using terms such as "completely illusory 'applications' of mathematics" (p. 812) and may inadvertently discourage junior researchers in pursuing the use of mathematical methods in psychology.

This comment does not venture into the validity of Brown et al.'s (2013) assertions, as this is partly addressed in the reply by Fredrickson (December 2013). Instead, using a simple hypothetical example, it offers a perspective on what constitutes a good mathematical model and evaluates diverging opinions on the role of such models in psychology and the social sciences. Mathematical models are useful insofar as they enable us to simplify and subsequently better understand complex processes and phenomena. Suppose, for example, that an experimental psychologist who, after administering a treatment to a subject, is able to measure anger levels on a 21-point rating scale (ranging from -10, indexing "no anger," to 10, indexing "extreme anger") at eight discrete time intervals (t = 0, 1, . . . , 7) observes the pattern summarized below:

Time	***t = 0***	***t = 1***	***t = 2***	***t = 3***
Level of Anger	**10**	**−8**	**6**	**−5**

Time	***t = 4***	***t = 5***	***t = 6***	***t = 7***
Level of Anger	**4**	**−3**	**2**	**−1**

Furthermore, suppose that other experimental psychologists independently replicate this experiment and find similar patterns of damped alterations in the levels of anger of their subjects. Could we write down a mathematical model that describes the observed changes in anger over time? Indeed, the first-order difference equation

$$\boldsymbol{Anger}_t = \boldsymbol{Anger}_0(-c)^t \qquad (1)$$

adequately describes how a subject's anger levels evolve over time for some constant $|c| < 1$, where $Anger_t$ is the observed level of anger at time t and $Anger_0$ is the initial level of anger. Instead of presenting large sets of data every time we discuss the effect of the treatment on an arbitrary subject's anger levels, we could simply state that the process follows Equation 1.

Therefore, an important property of mathematical modeling in a psychology context is its ability to summarize a complex process (e.g., the temporal evolution of an emotion) into a single equation. Of course, one can suggest other mathematical models that capture the data presented in our example. The researcher's goal is thus to choose the model that best represents the underlying psychological process under study. Myung (2000) argued that this is not necessarily the model that provides the best fit for a given set of data, since a highly complex model can provide a good fit without necessarily bearing any interpretable relationship with the true process (p. 190). Other than complexity, a second criterion that governs model selection is the extent to which its assumptions and predictions conform to reality. In economics, where the use of mathematical modeling is more prevalent than in psychology, there has been a long and interesting debate on this issue with no particular consensus in the literature.

On the one hand, a number of economists believe that mathematical models should describe real-world phenomena. George Ainslie, for example, has recently criticized the quasihyperbolic delay discount function that is used extensively by behavioral economists as the standard model of impulsiveness, noting that its popularity stems more from "a desire to preserve the tractability of classical economic discount functions than from either parsimony or a need to fit experience" (Ainslie 2012, p. 4). His critique highlights an apparent willingness on the part of social scientists to trade off the empirical validity of their mathematical models for the sake of achieving sharp but often flawed predictions. Other economists, such as Ariel Rubinstein, argue that mathematical models in economic theory are not meant to have any predictive power. In his account of dilemmas of an economic theorist (Rubinstein 2006), Rubinstein noted that "the word 'model' sounds more scientific than 'fable' or 'fairy tale' although I do not see much difference between them" (p. 881).

Nonetheless, despite no unified consensus on the role of mathematical models in the social sciences, I believe that psychologists should not necessarily shy away from incorporating these models in their toolkit because they offer a powerful method for capturing the underlying behavioral and cognitive processes that they study. However, as Brown et al. (2013, p. 801) cautioned, they additionally should verify that the primary conditions for their valid application have been met.

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